Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 52 (2016) 46 – 51

www.elsevier.com/locate/procedia

Changeable, Agile, Reconfigurable & Virtual Production

On Servitization of the Manufacturing Industry in the UK

James Huxtable[a] and Dirk Schaefer[a]*

[a]*University of Bath, Bath, BA2 7AY, UK*

* Corresponding author. Tel.: +44 (0)1225 386 163; *E-mail address:* d.schaefer@bath.ac.uk

Abstract

For a number of years, an increase in manufacturing-related service activities being provided by third parties rather than "in-house" departments has been observed. This trend appears to be strengthening in the context of the Industry 4.0 landscape. The purpose of this paper is to investigate in what sense and at what rate the domain of manufacturing in the UK is transitioning into a major service-oriented field and what types of manufacturing-related activities are most/least suitable for future servitization. Hence, the paper addresses the following questions: i) *To what extent has Servitization been adopted in the UK? – What impact is Industry 4.0 currently making?* ii) *What types of services are currently being offered as a result of industry 4.0?* iii) *What pros/cons/opportunities/threats does Industry 4.0 bring to British Servitization? – What wider economic issues will make an impact?* The research summarized in this paper presents an answer to the outlined questions and draws conclusions as to how this field may further develop in future. The main contributions of this research are the closing of a critical gap in literature by investigating the relationships between the two fields of Servitization and Industry 4.0, and the creation of a framework to allow companies to make themselves aware of Industry 4.0-related services, whilst ensuring these new service innovations are offered in-line with their current business model.

Peer-review under responsibility of the scientific committee of the Changeable, Agile, Reconfigurable & Virtual Production Conference 2016

Keywords: Servitization, Industry 4.0, Big Data, Cloud-Based Design and Manufacturing, Cyber Security, Autonomy

1. Introduction

The British Economy has transformed over the last half-century. In 1948, the UK Service sector contributed an estimated 46% to annual gross domestic product (GDP), by 2015, this figure had risen to 79% % ([1] [2]). Faced by intense competition from emerging markets, in recent years the UK Design and Manufacturing Industry appears to have also transitioned to services. Rolls-Royce now sells 'power by the hour', as opposed to aero engines. Their engines are sold on a contractual basis, where customers pay for the 'power', and Rolls-Royce ensure that power is continuously delivered by taking full responsibility for the engines maintenance and support [3]. This transition from a business model that revolves around the supply of products, to one that sells services or 'solutions' is known as Servitization. Along with Servitization, Industry 4.0, or 'the next industrial revolution', is changing the shape of the manufacturing sector. The first industrial revolution was said to have started in the 18th century with the rise of mechanical systems. The second saw the introduction of assembly lines and mass production at the beginning of the 20th century. The third then brought in computation and electronics in the early seventies. And now, the fourth industrial revolution introduces cyber-physical systems [4]. The merging of real and virtual worlds where equipment, products, and people are increasingly connected via the Internet. These connected systems interact to analyse data, predict failure modes, reconfigure themselves, and continuously adapt to changes in customer demand. Industry 4.0 as a vision was first developed within the German manufacturing sector [5] and is now interchangeable with other terms such as 'The Industrial Internet' [6]. Current literature separates these two paradigms,

Peer-review under responsibility of the scientific committee of the Changeable, Agile, Reconfigurable & Virtual Production Conference 2016
doi:10.1016/j.procir.2016.07.042

when in fact there appear to be many links between the two. Much of the literature around Servitization focuses on what *has* happened and attempts to clarify the concept as a viable business strategy. Industry 4.0 literature offers a holistic view of the technologies involved and the opportunities it presents, but largely focuses on its role within production, and only briefly mentions how it might affect the service side of manufacturing. It appears that Industry 4.0 presents many opportunities to firms who have or are looking to servitize. In light of this, the following research question was derived:

How will Industry 4.0 impact Servitization in the UK Design and Manufacturing Industry?

2. Servitization

Definitions: Published papers that show a strong relationship with the Servitization of manufacturing have risen exponentially over the last 20 years [7]. Various authors have published definitions for the term 'Servitization', three of which are outlined below in table 1:

Table 1 - Servitization definitions

Author	Definition
Andy Neely	*"The innovation of organisations capabilities and processes to better create mutual value through a shift from selling products to selling product service systems"*
Tim Baines	*"Servitization is the concept of manufacturers offering services tightly coupled to their products."*
Bart van Looy	*"A trend in which manufacturing firms adopt more and more service components in their offerings"*

Drivers: The Book 'Made to Serve' [8] provides a detailed breakdown of the drivers behind the Servitization paradigm –

Economic: Traditional manufacturing has shifted production away from western economies to emerging economies such as China and India. Lower labour rates in these nations means that western firms cannot compete on cost alone, and therefore, have transitioned to services.
Environmental: Global populations are rising, and as a result resources are being stretched. Western companies are looking to 'do more with less'. Services are considered to promote dematerialisation, and therefore, Servitization is seen as a viable strategy to meet these demands.
Social & Market: Evidence suggest that service contributions to an economy have a direct link to wealth. This suggest that demand for services in Western Economies is on the rise.
Technology: Information Communication Technology is one key enabler of Servitization. Developments in ICT mean that certain services such as product monitoring and GPS position tracking are available to offer now when they were not before.

2.2. Industry 4.0

Background: Industry 4.0 is a concept widely adopted in Europe, and in particular the German manufacturing sector [5]. The 4th industrial revolution is the next wave of manufacturing that introduces Cyber-Physical Systems into manufacturing production and services. Cyber-Physical Systems (CPS) are integrations of computation, networking and physical processes [9]. CPS technology enables real-time information extraction, data analysis, decision making, and data transmission. Leading to efficiency gains, real-time logistics and improved demand response [10]. In short, CPS drive 'smart manufacturing'. Historically the manufacturing sector has been through three industrial revolutions, with the fourth recently beginning around 2010 [4].

Elements: In the American manufacturing sector 'The Industrial Internet' is a term describing the sectors future outlook. General Electric, a multinational conglomerate, describe Connected Machines, Advanced Analytics and Automation as the three pillars of the Industrial Internet. Both 'Industry 4.0' and 'The Industrial Internet' are terms that describe in a similar way a digital paradigm shift in the manufacturing sector. Reviewing these paradigms, a number of related research fields and technology trends become apparent. Figure 2 details the key elements that form Industry 4.0.

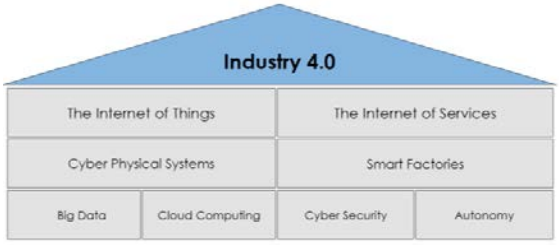

Figure 1- Elements of Industry 4.0

Drivers: In his book "The fourth Industrial Revolution", Klaus Schwab describes three key drivers of Industry 4.0 [11] –
Technology*:* Digital now acts as a platform to build billion dollar firms. The exponential growth of firms such as Uber and Air BnB has occurred because of digital.
Governments: The UK Government have recently published a report describing their vision for the manufacturing sector out to 2050. They describe a future 'digital manufacturing chain' and have policies in place to drive this change.
Industry: Firms such as GE, Siemens, ABB and Intel are all shifting their srtategy towards embracing Industry 4.0 or 'The Industrial Internet' ([12] [13] [14] [15]).

3. Research framing

In-order to address the previously stated primary research questions, three secondary research questions were articulated:

1. *To what extent has Servitization been adopted in the UK – What impacts is Industry 4.0 making?*

2. *What types of Services arise as a result of Industry 4.0?*

3. *What strengths/weaknesses/opportunities/threats does Industry 4.0 present to Servitization? – What wider economic issues will make an impact?*

To answer the before-mentioned questions, firstly, publically available annual reports of 57 UK-based manufacturing firms were analysed. Then, a comprehensive literature review was conducted. This aimed to identify Industry 4.0-related services. Finally, the impacts of Industry 4.0 on Servitization have been assessed by performing a SWOT analysis. Here, some of the wider economic influences firms must be aware of are discussed. This section has drawn insights from the previous research, along with related ideas from existing current literature. The report will now present to key findings related to each of the research questions outlined.

4. The current state of Servitization and Impacts from Industry 4.0

A total of 57 publically listed firms in the UK have been assessed; with three questions being asked. This section presents each question, followed by the solution derived and the corresponding implication on this research.

4.1. Key Findings

How many firms have adopted Servitization-based business models? – Looking into a given firms annual report, one can observe whether or not that firm derives income from both products and services, and hence, are said to have 'Servitized', to some extent. Of the 57 firms analysed, 61% are currently offering a clearly defined product-service mix, with 39% indicating they generate revenue purely from the sale of goods. This backs up current literature suggesting that Servitizaiton-based business models are becoming increasingly common within the UK Industry. It also validates that future research aimed at merging Industry 4.0 and Servitization would have value within Industry.

What percentage of revenue are firms generating from Services? – 27 of the 35 firms who had clearly adopted a Servitization-based business model provided a quantitative breakdown of the revenue they derived from both products and services. Results indicated that, on average, income from services was 27%. Furthermore, a distribution analysis was undertaken. It highlights that 75% of the firms are deriving less than 40% of their revenue from Services. In-line with previous studies, this suggests that many firms are not reaching the 50:50 ratios of leading firms in the field of Servitization (see section 2.1). Hence, they could look into growing their Service sector. This report will go on to discuss how they might achieve this growth through Industry 4.0 related concepts.

How many firms are offering services related to Industry 4.0? – Looking at the current services offered by each firm, we asked, *"Is this company offering any services directly related to the elements of Industry 4.0? (yes/no).* The results showed that 35% of firms were offering services related to Industry 4.0. This indicates that a large proportion of the companies who have adopted Servitization-based business models, are currently not harnessing the full potential of industry 4.0 within their service offerings. The research hence goes on to address this by investigating the types of services manufacturing firms can look to offering as Industry 4.0 matures.

5. Industry 4.0 Services

Looking into 'elements of Industry 4.0', outlined in section 3, the services arising as a result of The Internet of Things & Services, Big Data, Cloud Computing, Cyber Security and Autonomy have been identified and discussed. The final section integrates the new service offerings identified with current Servitization literature to form an I4 Servitization framework.

5.1. Key Findings

The Internet of Things & Services: The Internet of Things can be defined as *"A global infrastructure for information and society, enabling advanced services by interconnecting (physical and virtual) things based on ICTs"* [16]. Furthermore, the Internet of Services is defined as *"A system that systematically makes use of the internet for new ways of value creation in the service sector"* [17]. Reviewing literature around the Internet of Things and The Internet of Services a clear link has been made. The Internet of Services describes how there will be a vast new range of Services available to consumers across all industries; these services will take place online as a direct result of the Internet of Things.

Big Data: Ed Dumbhills provides a definition for 'Big Data' in his article 'Making sense of Big Data'; *"Big data is data that exceeds the processing capacity of a conventional data base"* [18]. To gain insights from these data sets, 'big data analytics' must be utilised. This is a category of analytics that uses advanced techniques to create value from large, diverse data sets containing both structured and unstructured data [19]. Table 2 presents a summary of the Services identified to be arising as a result of the Big Data trend:

Table 2 - Services arising as a result of Big Data

Service	Description
Condition Monitoring	Using embedded sensors, software and Big Data algorithms to obtain live information regarding the current state and performance level of a product
Predictive Maintenance	Using embedded sensors, software, and Big Data algorithms to intelligently predict when a failure will occur.
Data Re-sell	Selling data generated from smart products to third parties.
Advanced Pricing Models	Embedding products with sensors, software and Big Data algorithms that measure KPI's. This allows manufacturers to offer performance-based pricing models. Consumers are hence paying for a service solution.
Big Data Consulting	Manufacturing firms can sell their core competencies in analytics in order to advise other firms in different

	industries on how to harness Big Data.
Big Data Outsourcing	Firms with access to advanced analytics tools can outsource these 'as a service' to other firms to utilise.

Cloud Computing: In this section we outline the services arising through Cloud Computing, and more specifically, Cloud Based Design and Manufacturing. CBDM is a research field that integrates Cloud Computing and traditional product design and manufacturing. CBDM is described as a service orientated product development model in which service consumers are able to design and make products through utilising IT and Manufacturing resources online. There are four service categories commonly described; Hardware-as-a-Service, Software-as-a-Service, Platform-as-a-Service and Infrastructure-as-a-Service [20]. Table 3 presents services identified within each service category:

Table 3 - CBDM Services

Service	Description
Hardware as a Service	- **Machines & Tools as a Service**: Manufacturing firms can offer remote access to their machines and tools online in the cloud. - **Testing equipment as a Service:** Manufacturing firms can offer remote access to testing equipment (e.g. Wind Tunnels) as an online service.
Software as a Service	- **Product focused SaaS**: Firms provide software that runs in the cloud, and enhances the functionality or user experience in relation to the product being sold. - **Software outsourcing as a Service**: Manufacturing firms often development their own sophisticated software. Here, companies offer access to this software as an online service to others.
Infrastructure as a Service	- **Virtual Machines as a Service:** Manufacturing firm often invest heavily in their own computational infrastructure. Here, companies provide remote access to these power processors via the cloud.
Platform as a Service	- Services in this sector are often provided by dedicated 'pure service' IT firms. Therefore, PaaS offers limited options for manufacturing firms to utilise in their servitization strategy.

Cyber Security: Cyber security is the protection of theft or damage to IT hardware, software and the data stored on the systems [21]. The growth of Cyber Physical Systems within Industry 4.0 means that the Cyber Security market is on the rise. HIS, an information & analysis consultancy, have predicted a steady growth rate of 12% out to 2019 for the market, leading to an estimated market size of $1.2Billion. Table 4 presents a range of services that manufacturing firms could look to offer alongside their connected products:

Table 4 - Cyber Security Services

Service	Description
Cyber Security Consulting	- Firms offer advice and guidance with regards to Cyber security strategy at a top level.
Risk Management	- Services related to the prevention of Cyber Attacks.
Threat Monitoring & Detection	- Providing software and hardware that allows cyber threats to be monitored and detected, as an additional service to support the product.
Cyber Incident Response	- Firms who produce the products take charge to limit damage and prevent further attacks as a result of a cyber-attack.
Training	- Training services which equip those who will interact with the products with the knowledge and best practices to limit the likely hood of attacks taking place.
Cyber security packages	- Firms can offer differing levels of cyber security packages in relation to the products being sold. Basic subscriptions might include anti-malware software as a service; these can be built on by offering monitoring, detection, training, etc.

Autonomy: Autonomy is not a new concept, it was in fact at the very heart of the third industrial revolution. However, in light of industry 4.0, the world of 'autonomy' as we understand it today is changing. Within the manufacturing sector robots have long been used to streamline production lines and improve efficiencies. Yet with the rise in the IoT and artificial intelligence, robots (autonomous machines) are becoming more flexible, cooperative, and beginning to interact with one another, as well as humans [22]. Table 5 summarises that services identified that manufacturing firms can look to build into their service strategy:

Table 5 - Autonomous Services

Service	Description
Safety Services	- Firms offer additional training, equipment and advice with regards to the best practices to prevent accidents when humans integrate with autonomous machines.
Autonomous Information	- Information such as status updates, damage and performance are provided as an optional additional service to supplement the product. The information is programmed to be sent autonomously, at the best possible time.
Autonomous Functionality	- Taking a common product (Eg Car), and providing the option for it to be autonomous as an additional service. Users pay a premium the functionality; suppliers put in place guaranteed levels of performance.
Automated Services	- Using autonomous robots to provide the services that humans currently are. For example, amazon drone delivery.

I4 Servitization framework: Servitization literature commonly describes three categories of services that manufacturing firms can offer. Base services are those that are "outcome focused on product provision", for example, spare parts. Moreover, intermediate services are those centred on enhancing the products use and condition, for example, helpdesks or conditioning monitoring. Finally, advanced services are described as those focused on the performance of the product [8]. For example, when Rolls-Royce sell 'power by the hour', this is considered to be an advanced service because they are selling a solution with contractual guarantees. The I4 Servitization framework merges the Industry 4.0-related

services previously discussed with these service categories. This acts as a tool that businesses can use to firstly identify the Industry 4.0 services, and secondly, ensure the services are offered in-line with their current Servitization strategy. Typically, firms would begin selling base services, and develop these services through the intermediate phase with the aim to offering advanced services in the future. Advance services are said to come with a range of complexities that effective delivery can take substantial time, resources and planning. Figure 2 shows the I4 Servitization framework designed, the 3rd layer, flexibility, is there to indicate that many of the services could be offered on all three levels. Showing that a given service can be offered utilising a range of pricing models.

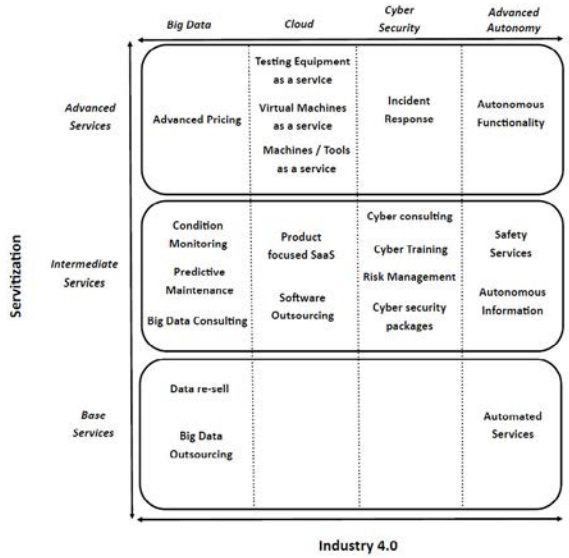

Figure 2 - I4 Servitization framework

7. SWOT Analysis

A SWOT analysis, in this context, has been performed to summarise the internal and external strengths, weaknesses, opportunities and threats that a company should be aware of when deciding whether or not to integrate Industry 4.0-related services within their business strategy. This section draws on observations made through research and the case studies, along with insights from relevant related literature.

7.1. Strengths

Financial Gain: The research has identified a number of services that firms can utilise to grow their service revenue. Previous research ([8] [23]) suggest that service profitability can be 2-3 times of the sale of products. Therefore, it is logical to conclude that similar financial gains could be achieved through Industry 4.0 service deployment.

Competitive Advantage: The research here indicated that Industry 4.0-related services are not common within industry, therefore, offering them would lead to a certain level of differentiation within a given market.

7.2. Weaknesses

The Service Paradox: The costs of delivering Industry 4.0-related services over a sustained period of time are uncertain. This is very much in-line with the 'service paradox', which describes how some manufacturing firms have experienced a dip in revenue and operating margin as the services they are offering mature [24].

Resistance to Change: Deploying the Industry 4.0-related services discussed in this research would require significant organisational change. McKinsey highlight one major factor contributing to the failure of change programs is employee resistance [25]. Firms wishing to offer Industry 4.0 services must address this issue in the development phase.

Shifting Values: If a firm were to start offering services related to, for example, Cyber Security, and this was a new market for them, it could shift their focus away their current core competency, and gives rise to the potential of them becoming a conglomerate.

7.3. Opportunities

Government policy: The UK government have begun to recognise how the manufacturing chain is changing and is becoming increasingly 'digitalized'. They now have various policies in place to assist the digital transformation, which with assist firms wishing to offer the services discussed in this research [26].

Exponential Technology: Research suggest that the technology sector is growing at an exponential rate [27] . This has been driven by Moors Law, which describes how the capacity of bandwidth, storage and processing power doubles every 18 months. This will act has a catalyst for the technology driving Industry 4.0 services to Industry.

7.3. Threats

Cyber Security: This research has presented Cyber Security as an opportunity for revenue growth. There are however a number of related threats it presents. For example, customers might grow to expect their connected products to be cyber-protected, and not accept paying additional fees to achieve this. Furthermore, standards and regulations for Industry 4.0 cyber security are not yet mature, a lack of these could prevent firms deploying the services discussed.

Infrastructure: With millions of devices set to be operating on the 'Internet of Things', questions are arises about whether or not the UK has the public infrastructure to turn this vision into a reality. Customers and machines will require fast, reliable internet connections from anyway. A lack of the IT infrastructure needed to achieve this would be detrimental to the success of the services discussed.

Workforce Skills: Industry 4.0 services are largely driven by digital technology. This means that manufacturing firms wishing to design and offer them must have employees with exceptional IT, electronics and robotics skills. A lack of them could be one the biggest barriers to the services success.

8. Conclusions

Based on the research conducted to address the primary and secondary research questions stated at the beginning of this article, the following conclusions can be drawn:

- 75% of firms assessed are deriving less than 40% of their revenue from services. In-line with previous studies, this suggests that many firms have the capacity for service sector growth.
- 35% of the UK firms analysed were offering services related to Industry 4.0, this highlights that Industry 4.0 is beginning to make an impact on Servitization, yet many firms could do more to build in Industry 4.0 in their service strategy.
- Twenty Industry 4.0-related services have been identified and discussed. This provides knowledge and ideas as to how firms can grow their service sector through Industry 4.0.
- The SWOT analysis highlights benefits to offering Industry 4.0 services – yet also highlights some very important wider economic factors that firms must be aware of before investing in the services innovations presented.

References

[1] J. Jones, "UK Service Industries: definition, classification and evolution," Office for National Statistics, London, 2013.

[2] Office for national statistics, "Index of Servcies, November 2015," 2016. [Online]. Available: http://www.ons.gov.uk/ons/rel/ios/index-of-services/november-2015/index.html. [Accessed 4th February 2016].

[3] D. Smith, "'Power by the hour': The role of technology in re0shaping business strategy at Rolls-Royce," *Technology analysis and strategic management* , vol. 25, pp. 987-1007, 2012.

[4] D. Schaefer, "An Investigation Case Study Apporach," ME40049 Innovation and Advanced Design, University of Bath, Bath, 2015.

[5] D. R. C. Schlaepfer, "Industry 4.0 Challenges and solutions for the digital transformation and use of exponential technologies," 2015. [Online]. Available: http://www2.deloitte.com/content/dam/Deloitte/ch/Documents/manufacturing/ch-en-manufacturing-industry-4-0-24102014.pdf. [Accessed 2016 May].

[6] P. Evans and M. Annunziata, "Industrial Internet: Pushing the boundaries of minds and machines," November 2012. [Online]. Available: http://www.ge.com/docs/chapters/Industrial_Internet.pdf. [Accessed 2016 May].

[7] T. B. a. H. Lightfoot, "The servitization of manufacturing - A systematic literature review of interdependent trends," *International Journal of Operations & Production Managment*, vol. 33, 2012.

[8] H. Lightfoot and T. Baines, Made to Serve, London: Wiley, 2013.

[9] P. Asare and D. Broman, "CPS," Cyber Physical Systems, 13th March 2012. [Online]. Available: http://cyberphysicalsystems.org/. [Accessed 2nd May 2016].

[10] Y. Xuejun, H. Cai and Y. Hehua, "Cloud-assisted industrial cyber physical systems: An insight," *Microprocessors and Microsystems*, vol. 39, no. 8, pp. 1262-1270, 2015.

[11] K. Schwab, "The Fourth Industrial Revolution," World Economic Forum, 2016.

[12] General Electric, "The Industrial Internet," GE, 2016. [Online]. Available: https://www.ge.com/digital/industrial-internet. [Accessed 3rd May 2016].

[13] H. Kagermann and W. Wahlster, "Industrie 4.0 - Smart Manufacturing for the Future," German Trade and Investment, July 2014. [Online]. Available: http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Brochures/Industries/industrie4.0-smart-manufacturing-for-the-future-en.pdf. [Accessed 3rd May 2016].

[14] C. Pone, "Connecting the World - Industrie 4.0," 2013. [Online]. Available: http://new.abb.com/docs/librariesprovider20/Contact-magazine/contact_middle-east-industry-4-0-dec2014.pdf. [Accessed May 2016].

[15] Intel, "Collaboration Accelerates the Internet of Things and Industry 4.0," Intel Corporation, 2015.

[16] ITU, "The internet of things global standard initiative," ITU, 26th June 2015. [Online]. Available: http://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx. [Accessed 2nd May 2016].

[17] O. Terzidis, D. Oberle and K. Kadner, "The Internet of Services and USDL," 2012. [Online]. Available: https://www.w3.org/2011/10/integration-workshop/p/USDLPositionPaper.pdf. [Accessed 2nd May 2016].

[18] E. Dumbill, "Making sense of big data," *Making sense of big data*, vol. 1, March 2013.

[19] IMB, "What is Big Data Analytics," 2016. [Online]. Available: http://www-01.ibm.com/software/data/infosphere/hadoop/what-is-big-data-analytics.html.

[20] D. Wu, D. Schaefer, and D. Rosen, "Cloud-Based Design and Manufacturing: Status and promise," *Cloud-Based Design and Manufacturing* , pp. 1-24, 2014.

[21] M. Gasser, Building a secure computer system, New York: Van Nostrand Reinhold, 1988.

[22] M. Lorenz, "Industry 4.0: The future of productivity and growth in the manufactuing sector," Boston Consulting Group, 9th April 2015. [Online]. Available: https://www.bcgperspectives.com/content/articles/engineered_products_project_business_industry_40_future_productivity_growth_manufacturing_industries/. [Accessed 23rd March 2016].

[23] P. Koudal, "The Service Revolution in Global Manufacturing," 2006. [Online]. Available: http://www.apec.org.au/docs/2011-11_training/deloitte2006.pdf. [Accessed May 2016].

[24] A. Neely, "Exploring the financial consequences of the servitization," *Operations Mangment Resources*, p. 1:103–118, 2009.

[25] S. Blackburn, S. Ryerson, L. Weiss, S. Wilson and C. Wood, "How do I implement complex change at scale?," McKinsey and Company, London, 2011.

[26] Goverment Office for Science, "THE FUTRUE OF MANUFACTURING: A NEW ERA OF OPPORTUNITY AND CHALLENGE FOR THE UK," Foresight, London, 2013.

[27] R. C. Schlaepfer and M. Koch, "Indsutry 4.0 - Challenges and solutions for the digital transformation and use of exponential technologies," Deloitte, 2014.

[28] T. Baines, H. Lightfoot, O. Benedettini and D. Whitney, "The adoption of servitization strategies by UK based manufacturers," *Journal of Engineering*, vol. 224, 2009.

[29] T. Baines and V. Gauang Shi, "A Delphi study to explore the adoption of servitization in UK companies," *Production , Planning and Control*, vol. 26, 2014.

[30] H. GEBAUER, E. FLEISCH and T. FRIEDLI, "Overcoming the service paradox in manufacturing companies," *European Management Journal*, vol. 23, no. 1, pp. 14-26, 2005.

[31] European Parliament, "Industry 4.0 - Digitilsation for productivity and growth," European Parliament, 2015.

[32] Caterpillar, "Enterprise Strategy," Caterpillar, 2014.

[33] S. V. a. J. Rada, "Servitization of Business:," *European Management Journal* , vol. 6, no. 4, 1988.

[34] T. Baines and H. Lightfoot, "The servitization of manufacturing: A literature review," *Journal of manufacturing and technology management* , vol. 20, pp. 547 - 567, 2009.